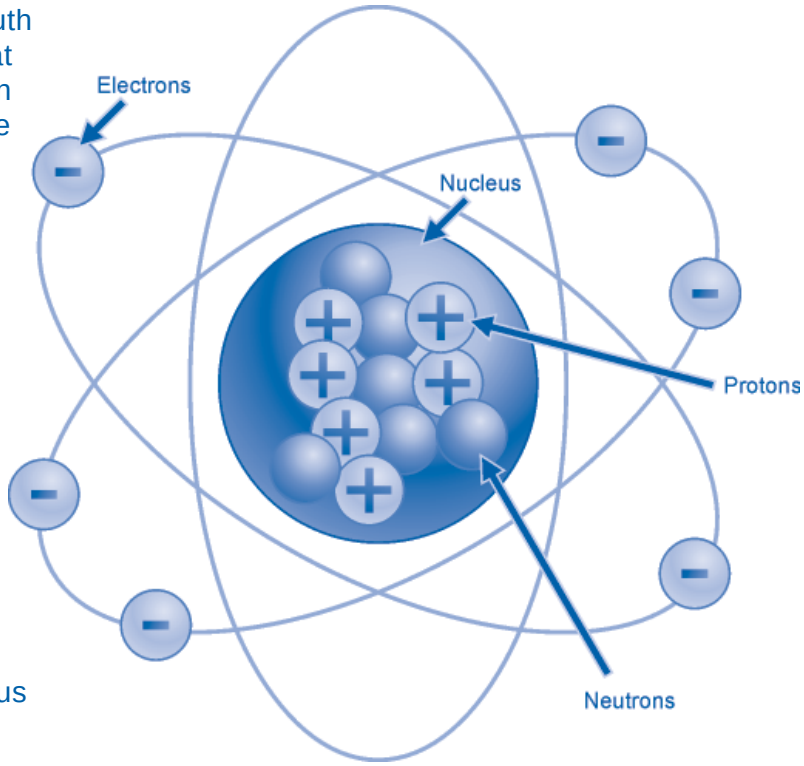
Chapter 5

Nuclear Energy

Nuclear energy plays a major role in South Carolina's energy picture and holds great promise for our energy future. It offers an alternative to fossil fuels, but at the same time carries with it the need for responsible use.



What is nuclear energy?

Nuclear energy is energy released by a nuclear reaction. The process of releasing energy from atoms is difficult to achieve. To understand it, you need to know that *matter*—which is everything that occupies space — is made up of atoms. In the center of every atom is a *nucleus*. Inside the nucleus are particles known as neutrons and protons. Traveling around the nucleus are electrons.

In the diagram of a carbon atom shown here, there are an equal number (6) of protons and neutrons in the nucleus. Six electrons circle the carbon nucleus.

Scientists have learned that when some atoms are bombarded by neutrons they can be made to split, releasing great quantities of heat energy. The process of splitting atoms to release energy is known as *fission*.

When an atom splits, neutrons from its nucleus are shot out at high speeds. They, in turn, cause other atoms to split. A *chain reaction* is thus set in motion.

The first controlled nuclear chain reaction took place at the University of Chicago on December 2, 1942 under the direction of Enrico Fermi. This event ushered in the Atomic Age.

How Nuclear Energy Is Produced

The vast power of nuclear energy can be made to work for us. For example, all nuclear plants convert the nuclear energy in uranium (a very dense metal used as an abundant source of concentrated energy) to electrical energy we can use. When the heat energy produced by fission is transferred to water, it creates steam. The steam is then used to power a generator to make electricity.

How A Nuclear Plant Works

In a nuclear power plant, fission occurs in the *nuclear reactor*. The heat energy produced by fission is captured to use in making steam to run the plant's generators.

In the diagram below, you can see how a nuclear reactor works. Uranium is the fuel used in nuclear power plants. Uranium pellets are stacked in long, metal fuel rods, which are bundled together to form fuel assemblies. These assemblies are then placed inside the reactor.

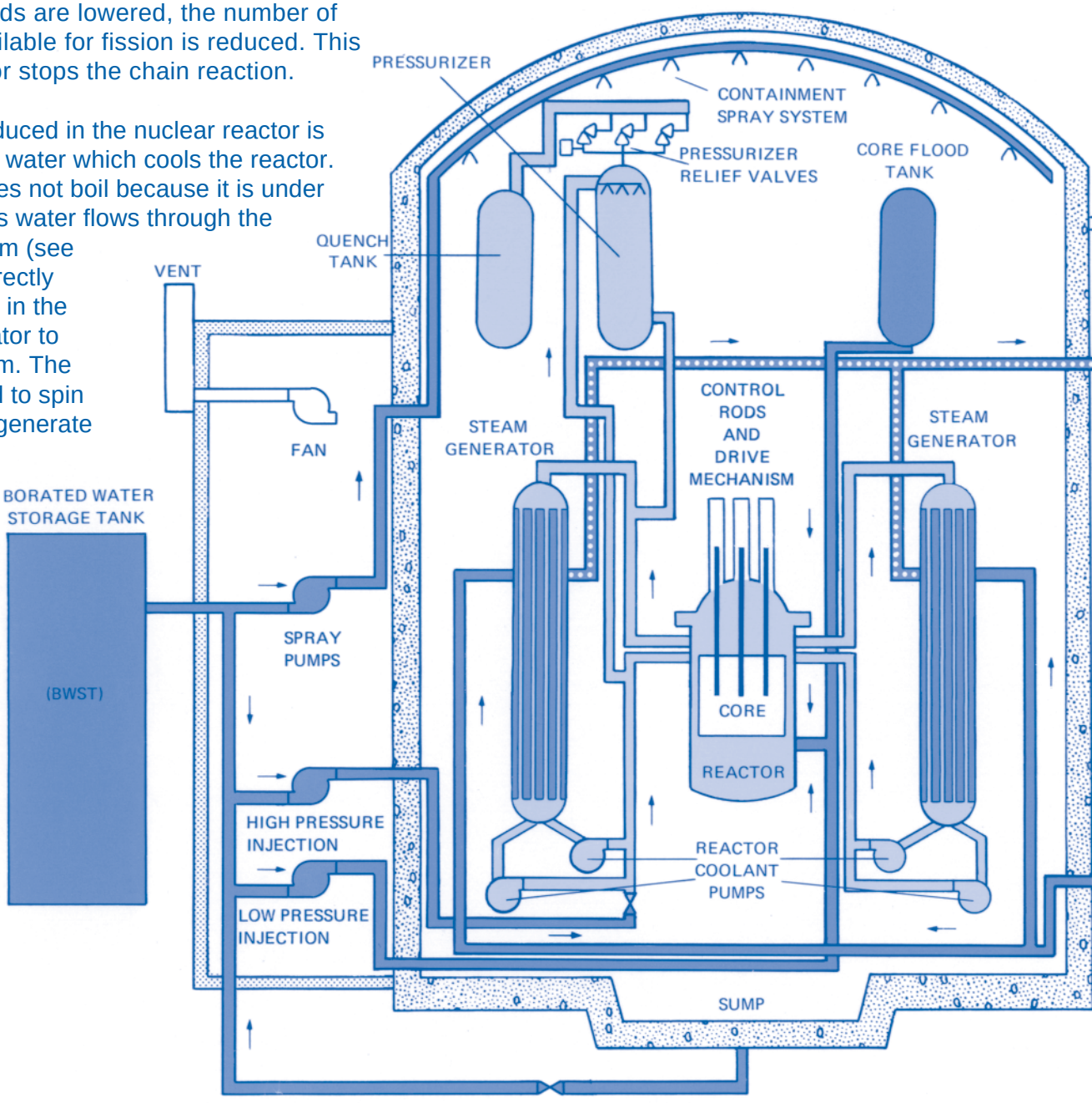
To regulate the fission process, control rods (steel rods containing boron) are used. They act as “neutron sponges.” By raising or lowering the control rods into the reactor, the chain reaction is increased or decreased. For example, when the control rods are lowered, the number of neutrons available for fission is reduced. This slows down or stops the chain reaction.

The heat produced in the nuclear reactor is transferred to water which cools the reactor. The water does not boil because it is under pressure. This water flows through the primary system (see diagram) indirectly heating water in the steam generator to produce steam. The steam is used to spin turbines that generate electricity.

Water in a closed system is used to condense the steam. The steam is then returned to the generator to be reused.

Using Nuclear Energy Responsibly

In a world with limited fossil fuels, many people feel nuclear energy has great prospects. It is considered “clean energy” by some. Nuclear energy does not pollute the atmosphere because the fuel is not burned.

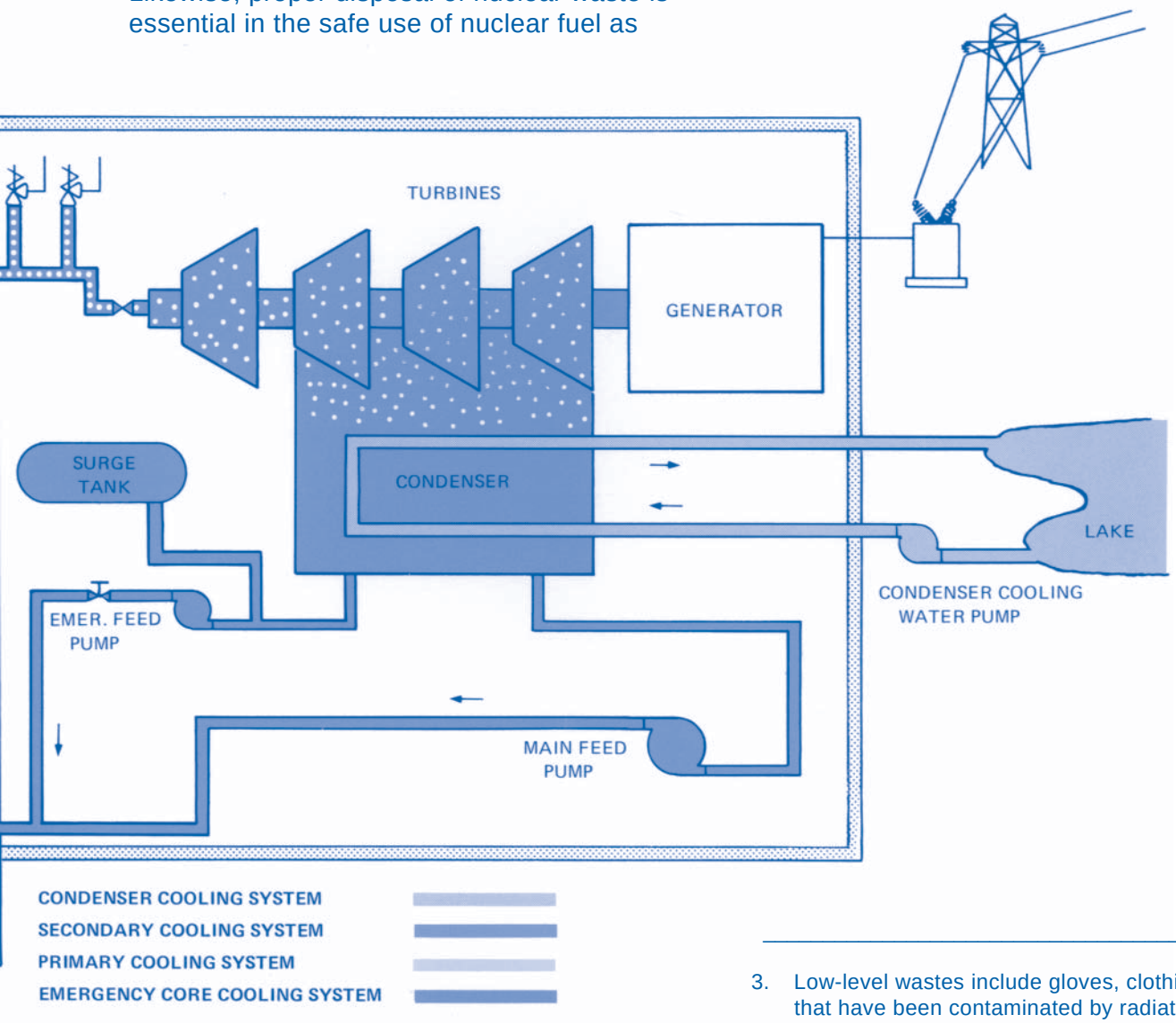


Two main concerns do, however, persist with nuclear energy — radiation and waste disposal. Every time fission occurs, invisible particles are released. These particles, or *radiation*, can be harmful. To prevent radiation from escaping the reactor in which it is isolated, many safeguards have been put into place.

U.S. nuclear power plants are tightly regulated to make sure radiation leakage does not occur. In fact, no nuclear facility can be built or operated without a license from the U.S. Nuclear Regulatory Commission (NRC). Power plants are carefully monitored by NRC inspectors, as well as power plant employees.

Likewise, proper disposal of nuclear waste is essential in the safe use of nuclear fuel as energy. This is especially important in South Carolina since Barnwell County is one of three sites in the United States where low-level nuclear wastes[3] are stored. Some of the precautions taken in handling nuclear wastes include:

- Burying the waste containers in waterproof trenches;
- Regularly checking nearby water wells to ensure that no radiation has escaped; and
- Closely monitoring the area to make sure the waste containers remain undisturbed.



3. Low-level wastes include gloves, clothing and tools that have been contaminated by radiation.

Nuclear Energy in South Carolina

Since the early 1970s, South Carolina has been a leader among states with regard to the use of nuclear power. Only Illinois and Pennsylvania produce more nuclear energy than South Carolina.

In South Carolina we have been able to reduce our use of fossil fuels because of our extensive use of nuclear energy. Nearly one-third (32.5 percent) of the state's energy needs are currently being met by nuclear energy. Nearly 57 percent of the electricity we produce comes from nuclear power.

When the Robinson Plant began generation in 1970, South Carolina became the first state in the South to use nuclear energy for electrical generation. Today there are seven nuclear plants operating in the state. As shown on the map on page 29 in Chapter 6, these include the three Oconee plants, H.B. Robinson in Darlington County, V.C. Summer in Fairfield County and the two Catawba plants in York County.

South Carolina's nuclear facilities have proven to be cost-effective investments. The Oconee facility paid for itself through energy savings in just eight years. In its first 10 years, it became the nation's leading producer of nuclear-generated electricity.

Radioactive Waste in S.C.

Because of South Carolina's investment in nuclear energy, state leaders in the 1960s and 1970s realized that the state would need a regional facility for the safe disposal of radioactive waste.

Radioactive waste comes in many forms. Familiar objects that we encounter on a daily basis can be considered radioactive waste if they become radioactively contaminated. These include uniforms, gloves, construction materials, and tools. Some radioactive waste is less familiar. Filter material used for capturing radioactive elements in the cooling water of nuclear power plants is a common form of radioactive waste. The processed residue from the manufacture of nuclear materials and nuclear weapons is also radioactive waste. Unless they are solidified or absorbed, these take the form of a liquid or sludge.

In the United States, radioactive materials are divided into two groups for purposes of permanent disposal. One group consists of wastes that can be disposed of in the upper 100 feet of the earth's surface in a disposal facility like the one in Barnwell County, South Carolina. This is called "near-surface" disposal. The other group consists of wastes that require a higher degree of isolation in a "deep geologic repository."

Deep Geologic Disposal in the U.S.

The only deep geologic repository currently operating is the federal Waste Isolation Pilot Project (WIPP) located near Carlsbad, New Mexico. The WIPP site accepts long-lived radioactive waste, known as "transuranic waste," from the Savannah River Site (SRS) in South Carolina and other U.S. Department of Energy (U.S. DOE) facilities across the nation.

Another deep geologic repository under development, the Yucca Mountain Site (YMS) in southeast Nevada, will accept spent nuclear fuel from commercial power plants. YMS also will accept high-level radioactive waste that is now stored at U.S. DOE facilities. Included in this will be plutonium wastes and other high-level waste from SRS and other federal sites. Until the YMS begins accepting waste, most spent fuel from nuclear power plants will continue to be stored at the 110 nuclear reactor facilities across the nation in water-filled fuel pools.

The Barnwell Near-Surface Disposal Facility

The U.S. government requires that near-surface radioactive waste disposal facilities be owned by the federal government or by state governments. This is because these facilities will require monitoring, custodial care, and restricted access long into the future. The near-surface disposal facility in Barnwell County is owned by the State

Budget and Control Board and is operated under a lease agreement by a private company. There are currently only two other such disposal facilities for commercially generated radioactive waste in operation in the United States. One is located in eastern Washington State and the other is west of Salt Lake City, Utah.

The facility in Barnwell County was opened in 1971 and has disposed of more than 27 million cubic feet of waste over an area of 100 acres. Waste is placed in large, specially-built trenches. Each trench has a gently sloped floor to prevent accumulation of water during the period the trench is open. A layer of gravel separates the waste packages from any ground water that may intrude during waste emplacement operations. When filled, each trench is capped with a sandy clay material in order to channel surface water away from the trench area. When the site is closed, a permanent multi-layer cap consisting of both natural and synthetic materials will be placed over the entire site as further protection against the intrusion of surface water into the trenches.

As with the other similar facilities, there are strict regulatory limits on the form of the wastes that can be accepted. Wastes cannot include free-standing or unabsorbed liquids. They cannot include chemically hazardous materials. Waste packages must be generally free of air pockets that could cause the trench caps to sink.

Federal and state regulations require an environmental monitoring program to detect any radioactivity outside the trenches. The monitoring program must continue for at least 100 years after the site is closed.

Future of the Barnwell Site

In late 1999, a Governor's task force recommended that a portion of the remaining 3 million cubic feet of disposal capacity at the Barnwell disposal facility be saved for use by nuclear power plants and other industries located within the state. These seven nuclear plants will require a large amount of disposal space in future decades. The task force was concerned that if South Carolina did not take action, the Barnwell site would be filled with waste from other states long before S.C. industries needed it.

Following a recommendation by the task force, the S.C. General Assembly in 2000 joined a three-state alliance with Connecticut and New Jersey called the Atlantic Interstate Low-Level Radioactive Waste Compact. Because the Atlantic Compact had been authorized by the U.S. Congress to limit access to its regional disposal facility to the member states only, this provided the legal authority the state needed to keep out waste from other regions.

The 2000 law also phases out acceptance of radioactive waste from across the nation. By 2009, the Barnwell site may not accept any waste from outside the three-state region.

Conclusion

South Carolina has long embraced the use of nuclear energy. Because the state produces no fossil fuels, nuclear energy allows it to be less dependent on these resources. Clearly, nuclear energy will continue to be important to South Carolina's future.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